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American Meteorological Journal.

A Monthly Review of Meteorology, Medical Climatology and Geography.

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THE AMERICAN
METEOROLOGICAL JOURNAL.

VOL. III. ANN ARBOR, AUGUST, 1886. No. 4.

CURRENT NOTES.

THE PAINTER'S WIFE'S ISLAND.—What Africa was to the ancients in the way of producing novelties, America has been to the moderns. Utopia, New Atlantis, El Dorado, Fairy Land, and the Painter's Wife's Islands, were all said by the wits of the sixteenth century to be portions of this lately discovered quarter of the globe. "The Painter's Wife's Island," said Dr. Huelyn, many years ago, "is an island of this tract, mentioned by Sir Walter Raleigh in his History of the World; of which he was informed by Don Pedro de Sarmiento, a Spanish gentleman employed by his king in planting some colonies on the Straits of Magellan, who, being taken prisoner by Sir Walter in his going home, was asked of him about some island which the maps presented in those straits, and might have been of great use to him in his undertaking; to which he merrily replied, that it was to be called the Painter's Wife's Island, saying, that while the painter drew that map, his wife sitting by desired him to put in one country for her, that she in her imagination might have an island of her own. His meaning was, that there was no such island as the maps presented. And I fear the painter's wife hath many islands, and some countries too, upon the continent, in our common maps, which are not really to be found on the strictest search." Of such sort, also, are what are called the Lands of Chivalry; of which the Isle of Adamants, in Sir Huon of Bordeaux; the Firm Land, in the history of Amadis de Gaul; the Hidden Island, and that of the sage Alart, in Sir Palmerin of

England; as also the Island of Barataria, of which the famous Sancho Panza was some time governor, and the kingdom of Micomicona; "which, as the ingenious author of the History of Don Quixote merrily observeth," said Dr. Huelyn, "are not to be found in all the map."

THE AMERICAN GEOGRAPHICAL SOCIETY.—According to Dr. Wichmann there are now 94 geographical societies, representing 20 different countries. Curiously enough France heads the list with 26 societies; then comes Germany with 24, while Great Britain, with all its colonies, has only 5 and the United States 2. Russia has 4, Switzerland 6, and Brazil 3. The largest society is the Royal Geographical of London with 3,400 members; then comes the Paris Society with 2,250, then the American with 1,400.

The United States thus stands low in the scale as to number of societies though fairly high in membership. The American Geographical Society publishes occasional bulletins which are not very accessible to the general public. They are in general issued only to fellows for whom the fees are ten dollars annually. The objects of the society are, according to the official publication, to encourage geographical exploration and discovery; to investigate and disseminate new geographical information by discussion, lectures and publications; to establish in the chief maritime city of the country, for the benefit of commerce, navigation, and the great industrial and material interests of the United States, a place where the means will be afforded of obtaining accurate information for public use of every part of the habitable globe. The Society has been in existence thirty-three years. It has a geographical library of thirteen thousand volumes, and a large and very valuable collection of Maps, Charts, and Atlases relating to every part of the world. It publishes a Bulletin, an annual Journal, and co-operates and interchanges information with one hundred and twenty domestic and foreign Geographical and other Scientific Societies.

For the year 1885 there were two bulletins, comprising together 168 pages. In these two numbers Mr. David Dudley

Field discusses the nomenclature of our cities and towns. Mr. Ernest Ingersoll the fate of the wild animals of North America, Professor Hosford the Site of Norumbega and Mr. Wm. Bradford Life and Scenery in the far North. Bulletin No. 1 of 1886 is now before us and contains an article on mountaneering in British Columbia by Ernest Ingersoll and one on Persia and the Persians by ex-minister Benjamin, besides geographical notes by Mr. Geo. C. Hurlbert.

The articles usually bear the stamp of lectures before the Societies and are invariably interesting reading. This makes them very suitable for the general public and it is greatly to be regretted that they are not more accessible to the class of readers who would best appreciate them. Mr. Ingersoll's account of the Columbian Rockies is a charming one and, while it contains little exact information and perhaps no addition to geographical knowledge, it would, if more generally disseminated, tend to attract popular attention to the very interesting Columbian Mountains, the charms of which are little understood and appreciated. Mr. Benjamin's article sums up his experience of Persia and the Persians and is extremely interesting.

Circular Lately Issued by the New England Meteorological Society.—The council of the Society takes this opportunity of calling general attention to the object and work of the association.

The Society was formed in 1884: its constitution states that "its object shall be the cultivation of meteorological science in New England." All persons interested in this object are therefore invited to apply to the secretary for membership in the Society. The annual fee is three dollars. Members are entitled to attend and to vote at the meetings of the Society, and to a copy of its publications: members need not make observations.

The Society acts in co-operation with the United States Signal Service, and occupies in New England the same position as that taken by the State weather services in other parts of the country. All voluntary observers of the Signal Service in New England are desired to report to the Society. The Society encour-

ages the local display of weather signals, based on the daily predictions, issued from the Signal Office in Washington. (Correspondence concerning those signals in Connecticut should be addressed to the Observer, Signal Office, New Haven, Connecticut; from other parts of New England, to the Observer, Signal Office, Boston, Mass.

The fundamental work of the Society is the collection of systematic records of climatic elements, such as temperature, rainfall and the tide, made by trustworthy observers with accurate instruments. This work is in charge of the director. About one hundred and fifty observers are now co-operating in this task. Additional observers are desired, especially at points not now represented (see map on other side). Obervers need not take membership in the Society; the monthly bulletin is sent them without charge.

In order to insure accuracy of record, thermometers and raingauges belonging to observers regularly reporting to the Society, will be tested free of cost by Professor S. W. Holman, of the Massachusetts Institute of Technology, Boston. All instruments bought through the Society will hereafter also be tested in this way. (Correspondence should be addressed to the secretary.)

A monthly bulletin, prepared by the director, is published by the Society, containing a general statement of the weather for the month preceding that of its issue, a summary of observations collected, presented in tabular form, and a map showing graphically the mean diurnal range of the temperatnre and the total amount of precipitation. The map from the bulletin for March is reprinted on the other side of this circular. The bulletin is sent free to members and to regular observers; to others, the subscription price is one dollar a year, payable to the treasurer.

The Society holds regular meetings on the third Tuesdays of October, January and April, when communications of scientific interest are presented.

Special investigations may be undertaken from time to time; those that the Society is at present engaged in are the study of thunderstorms, under the direction of the secretary, and the ex-

amination of rainfall, temperature, etc., in general storms, by the director.

WM. H. NILES, Mass. Institute of Technology, Boston, Mass., President.

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COUNCIL OF THE SOCIETY.

DESERT OCEAN TRACTS.—The ocean, like the land has its paths of commerce, regular beaten tracks, and its out-of-the-way places where ships rarely venture. In the former sails are frequently seen, often many at a time, and a day rarely passes without one or more; in the latter the solitary whaler, fisher, or trader may pass weeks or months without the sight of a sail. Persons wrecked and cast away in the former will not fail of being soon seen and picked up; if in the latter they may well despair of ever being noted by mortal eye. The location of the desert tracts is pretty well known but it is vividly brought to view by the maps just published by the Meteorological Council of the Royal Society. This eminent meteorological board, in charge of the English weather service, has unsurpassed facilities for collecting marine observations and they have occupied themselves with it for many years. They collect the logs of ships and the notes of navigators and systematize and reduce them. Their accumulations are very great and in their late report they publish maps for each month on which are marked the number of days observations for each square of ten degrees of the ocean surface.

The numbers on these maps indicate the populousness, so to speak, of the square to which they belong. The most populous is the North Atlantic and next to this the South Atlantic. From 60° South latitude to 60° North there is hardly a square which is unoccupied. The most populous square is that covering Scotland. This is probably incidental to the source of information

and is not absolutely true. Next to this, and probably generally true, is the square just North of the equator and about half way between Africa and Brazil. The Indian Ocean is well covered especially the Bay of Bengal.

Naturally the Arctic and Ant-Arctic Oceans are deserts with only a few squares occasionally occupied. But the most interesting desert regions are in the sparsely populated Pacific, and the great region to the east of the East Indies is almost entirely vacant. It is an immense expanse, lying somewhat obliquely, lying lengthwise from not far South, East of Japan to the Society Islands, and in width from the Marshall and Gilbert groups to the Sandwich Islands. It is a region of about the size and shape of South America, and in these ten million square miles there are many squares of ten degrees each way in which not a single vessel has reported to the Met. Council in all the years in which observations have been collected. Cast away in this region would be a misfortune indeed. The hope of seeing a sail could not be entertained and the only safety would be in finding one of the small islands scattered at wide intervals and so low as to be easily passed.

Another desert tract, but very much smaller, lies east of the track of vessels passing from our west coast to New Zealand and west of the coast traffic of South America. Easter Island is near its center and it approaches the size of the great land desert, the Sahara.

Prediction of Frosts.—It is of very great importance in the spring and autumn months to be able to predict the occurrence of night frosts. The farmers and other cultivators understand that frosts are likely to happen only with a clear sky and dry air,—that is when radiation of heat from the soil to the sky is little impeded.

The meteorologist adds to this a more precise indication in the wet-bulb thermometer. The standing of this instrument indicates the dew-point, the temperature of which can be easily deduced from the reading of the instrument. The meteorological rule is: "*The temperature at night is not likely to fall below*

the dew-point of the late afternoon or early evening." If then the dew-point obtained in the evening is about 32° there will probably be no frost; if below, a frost will probably occur. The rule is generally true, the observation is easily made, and a small table would enable the farmer to easily and promptly deduce the dew-point, when the temperature of the air and that of the wet-bulb thermometer are known. The only trouble is that the observations must be made late in the day (the later the better), and then it may not be convenient to take precautions against frost.

Mr. A. Kammermann has recently attempted to obviate the difficulty mentioned above, and, in the course of his investigations, has hit upon the following rule: *The difference between the temperature shown by the wet-bulb thermometer at any fixed hour of the day and the lowest temperature in the following night is almost constant through the year.* For instance, he found that the temperature of the wet-bulb thermometer at Geneva, Switzerland, at 2 P. M. is uniformly about 4° C. (3.1° to 4.1°) above the minimum of the following night. If at 2 P. M. the wet-bulb shows 6° C., then the lowest temperature will be about 2° C., and there will be no frost; if, on the other hand, it shows 2° C., then the minimum will be about —2° C., and there will be a frost.

This, if generally true, is of much interest, as the observation is easy and the application extremely simple. The constant to be applied would probably be different for different places. The important question is, Is it a constant? It has been tried for Ann Arbor and, unfortunately for that place, it is not constant. It varies through about 25° F. The rule of Kammermann is not correct for Ann Arbor, but it might be well to try it elsewhere, though there is little prospect of its proving useful.

IT GREW SUDDENLY COLDER.—There is no doubt that the sensation of cold depends on many other things than the temperature. On a calm, clear, dry day, with the thermometer at twenty degrees below zero, the sensation may not be as uncomfortable

as on a wet, cloudy, windy day when the temperature is only at freezing. Apropos of this we clip the following from the *Jamestown* (*Dak.*) *Capital:*

The other morning when the Pacific Express arrived in Jamestown a large number of the passengers stepped out on the platform to inhale the salubrious ozone until the train should start on again. "What a bright, balmy morning," remarked a sentimental-looking gentleman. "Just like spring!" said another. "Wonder if it is always such fine weather in this country?" observed another. "Wonder what the temperature is this morning, anyway?" said a bald-headed man who had come out and was enjoying a promenade up and down the platform with nothing on his shining pate but a silk traveling cap. "Thirty-six below zero," casually responded Chief-of-police Schmitz, who supposed the remark was addressed to him. "Thirty-six below zero!" repeated the throng of travelers in concert, and immediately there was a rush for the coaches, and in less than one minute not a stranger was to be seen on the platform. If it were not for the thermometer it would hardly be realized that we had winter weather in this country.

TORNADOES IN CHINA.—This country is frequently visited by tornadoes, some of which have proved very destructive. A recent number of *Ciel et Terre* gives an account of a series of them which visited Shanghai, August 21, 1885. Two formed at first beyond the river, in the east, where enormous masses of black clouds were accumulated in the afternoon. One of them, on reaching the right bank of the Wangpoo, tore down and dissipated in air four Chinese houses, in sight of a policeman of the French concession. It then passed on to the river, met three foreign ships at anchor, and throwing one over on the side, carried away the awnings and everything on the others. It broke the chain of a vessel fastened to the quay and capsized Chinese boats, drowning those who were in them. On reaching the left bank, the tornado passed through the French concession, raising clouds of dust and carrying away heavy roofs, even those made of zinc or iron, carrying mattings and the débris of

tents and other light objects to a height of 450 or 500 feet.

The path of the tornado was about 300 feet broad. It passed 1200 or 1500 feet from the "Champlain," the commander of which says that during the passage his registering Richard barometer fell 1.5 mm. The figure of the tornado was, according to a competent observer, typical.

Five minutes after its disappearance a second or third formed close to it in the fields outside the city. It was observed by Mr. Dechevrens, director of the observatory at Zi-ka-wei. It was close by and appeared less compact and whitish than the first, which was seen at a distance. It was composed of numerous thin threads, much entangled, and slowly rising in spirals. Their combined effect was the cone which plainly turned from left to right. It did not reach the ground but rained a sort of indistinct column of dust which sought to unite itself to the hanging cone. It vanished after a few moments of agitation.

During the morning of this day the air was nearly calm at Zei-ka-wei, with slight zephyrs from the south-east and east. M. Deschevrens has made a special study of vertical currents of air, has devised an instrument for detecting them, and had fortunately such an instrument fastened under his Robinson's anemometer, about 130 feet from the surface. That morning, when the air was perfectly calm horizontally, the special instrument showed rapid vertical motions; when the zephyrs arose, these ceased.

Temperature in Cyclones.—Mr. P. Braunow has studied the distribution of temperature in cyclonic areas for Europe and has reached some interesting results which are published in Vol. IX of Dr. Wild's *Repertorium.* He finds that, on the average, if one stands at the center of the cyclone and looks in the direction of its motion, the area of greatest warmth is in front and to the right, that of greatest cold behind and to the left. He finds also that in winter the most of the cyclone is warmer than the average, in summer colder. This is, of course, largely due to the cloud-layer which prevents radiation in winter and insolation in summer.

If the cyclone be divided into four quadrants by a tangent through the center to the path and a perpendicular to this, also at the center, some interesting results are deduced. Starting with the front right hand quadrant and calling it I, the back right hand one II, and so on in succession, he finds that the maximum positive deviation from the normal temperature is in quadrant I and not far from the line which bisects its angle. For the maximum negative deviation the same is true for quadrant III. The temperature of quadrant I is always higher than the normal and of II it is always higher except in summer. The temperature of quadrant III is always lower than the normal, and that of IV is lower except in winter. The mean deviations from the normal (anomalies) for 76 cases for the seasons and quadrants are as follows:

Winter	5.°7C.	3.°4C.	—2.°3C.	0.°5C.
Spring	2. 9	0. 9	—1. 6	—0. 6
Summer	1. 5	—0. 2	—2. 1	—1. 2
Autumn	2. 6	0. 7	—1. 2	—0. 5

The minus sign indicates a negative deviation.

These results the author considers of practical value in predicting the weather.

Forest Fires in Washington Territory.—Forest fires form one of the most serious scourges of the Puget Sound country. It is a natural scourge because it is due to the highly inflammable character of the forests there. In another sense they form an artificial scourge as their origin is due to carelessness or to malice. They are common in the dry season of the year. They may begin as early as May. Early in last May the town of Farwell was entirely destroyed by one. July is generally the worst month and in last July the fires were especially destructive and general. We take the following graphic description of them about the middle of July from the *Northwest Enterprise* of Whatcom County.

"Extensive forest fires raged on Guemes and Fidalgo islands this week. On Tuesday the sky was lurid from smoke, which completely obscured the sun and imparted a strange, weird appearance to the landscape. The flames leaped up a hundred feet above the tops of the high-

est trees, and dense volumes of smoke ascended in portentous clouds above the island. At night the burning forest, as witnessed from the Fidalgo shore, presented a grand and imposing scene. The tall fire between two and three hundred feet high appeared like columns of flame from top to bottom. The roar of the flames as they rolled steadily on, accompanied with the thunder of falling timbers, presented an appalling scene.

At Anacortes the fire swept through the woods with alarming rapidity. Johnson's cabin, located on Amos Bowman's land, was wiped out, and scarcely a vestige remains where it stood. About twenty-five cords of wood, piled near the cabin, his tools and some other property were destroyed. Peter Nelson lost six hundred rails. Unless the rains set in soon, a fearful destruction of valuable timber is inevitable during this season.

Other and very serious fires have been raging on the mainland. In the Saamish valley serious damage has been done to the logging interests of that section. An exchange says: Its origin is somewhat uncertain, the fire coming over the hill back of McElroy's slashing, burning through it to the lower landing of Clothier & English's camp. The fire burned the three landings there, the greater part of their logging railroad, some eight bridges of McElroy's works, two houses occupied by the families of Barrett and Kitt, who are working in the camp, and some logs ready for hauling. There was little damage done to the standing timber. In all the fire swept over 1,000 acres of land. The damage to Clothier & English is about $2,000 in property destroyed, and not less than $4,000 loss in the interruption of the logging, as the works will not be repaired this year. McElroy's loss will also be severe.

Captain Reeder, whose trading steamer goes to that section, says: Forest fires are so destructive around Whatcom and Saamish that many families have been burned out. A great many houses, barns, fences, etc., have been destroyed. The Kallock colony near Saamish is almost destitute—and the end is not yet."

Not the least objectionable feature of these fires is the great volume of smoke they pour out, which hangs like a pall over the country for days or weeks afterwards. The smoke is so dense that it shuts out the view of distant mountains and makes the visit of the tourist in the dry season an undesirable one. The absence of rain to wash the smoke out of the atmosphere makes it drift farther and last longer than it would otherwise. One great fire in an unsettled part of the country may cover a region equal to half of Oregon or Washington with a smoke-cloud.

These fires are very destructive of fine timber, often wiping it out for many hundred acres at a time, and leaving behind a scene of desolation far surpassing those that follow a fire in Michigan or Pennsylvania. Pen can hardly depict the dreadful appearance after one of these great fires, but the most remarkable feature is the charred and blackened trunks, often yet standing to a height of one or two hundred feet. Fortunately for the forests (unfortunately for the settler) the soil has in it many of the seeds of the destroyed trees, and, as soon as one forest disappears, a dense and rapidly growing one spring up.

This plague, being of an artificial origin is not beyond a cure. The beginning of the fire is often found in sparks from a saw-mill or a locomotive or the embers of a hunter's fire. But they are probably far oftener due to the fires set to burn the "slashings" on newly cleared land. These are very inflammable and the fire sometimes breaks out from control and sets the neighboring woods on fire. An easy remedy would be to burn the slashings in the wet season when the forests are less likely to take fire.

THE ILLINOIS STATE WEATHER SERVICE was organized in July, 1877, with thirteen voluntary observers, under the direction of Hon. S. D. Fisher, Secretary of the Illinois State Board of Agriculture, who conducted the same until January, 1885.

A signal station was established at Springfield in 1877, and began to report to the State Director in February, 1878. Reports were first received from the station at Cairo in May, 1878, and from Chicago in August, 1879. In January, 1885, the number of regular observers was twenty-two, which number gradually increased until June, 1886, when reports were received from sixty-one stations, and three of the regular observers failed to get their reports in the hands of the Director in time to have them incorporated in the Weather Review.

Three of the observers have reported to the department ever since its establishment in 1877; three began in 1878; one in 1879; three in 1881; eight in 1882; two in 1883; three in 1884.

The remaining forty began making observations within the last eighteen months.

The Illinois Department of Agriculture publishes a monthly weather review of about thirty pages, which contains tables giving all the data collected by the observers, as well as a summary of the same by counties under the head of remarks, and an introduction which gives the most salient points and the phenomena of all kinds for the entire State. A summary of the observations is sent to the newspapers of the county in which the station is situated, and is published by them, thus giving every one in the county the benefit of them.

The review also contains a list of the stations in Illinois displaying the weather flags, which list is enlarged monthly as the people of the various towns of the State awake to the advantage of knowing the weather indications each morning. Much interest is being manifested in this branch of the service, and the efforts of a few enterprising men are making themselves felt over a large area of country. Illinois inaugurated the system of announcing the indications by means of steam whistles, the whistle at the Deaf and Dumb Asylum at Jacksonville being the first one in use.

A regular code of steam whistles has been formed and is uniform throughout the State. This plan is specially useful in agricultural districts, as the farmers can hear the whistle at a much greater distance than they can see the flags.

The Chicago and Alton Railroad Company has entered into the spirit of this work and delivers the dispatches to all points on their line, where requested, free of charge.

A Prophet, or a Dreamer of Dreams?—Last autumn there appeared at Richland, Kansas, a little folio called *The Future*, which proposed to predict the weather on certain principles which the editor, publisher, and proprietor, Mr. C. C. Blake, denominated astronomical. The paper has appeared monthly ever since, and seems to be prosperous. The editor has enlarged the scheme of sciences which are involved in his methods until they are now seven. He has also published his picture,

and he is a fine looking man. He has also published, from time to time, items of his history and his opinions on the most varied subjects, until probably a careful collation of them would make a tolerably complete biography. This collation has not yet been made by his admirers, probably because Mr. Blake can be relied on to do it himself in due time. No advertisements are taken for *The Future.* Its space is all reserved for the editor's own work, or for admiring comments from his friends.

As to the weather predictions, the report can not be made so favorable. As a contribution to what it is the fashion nowadays to call psychology, the periodical is as interesting as one of Ouida's novels, but for other purposes its usefulness is of the slightest. Still a little amusement can be drawn from this part if one will perform the necessary labor. I will perform it in one case for my readers. I will place in parallel columns Mr. Blake's predictions and the actual weather as given in the Weather Review. The month taken is the first one which comes to hand, viz., NOVEMBER, 1885:

Blake's Prediction.	*Actual Weather.*
"My calculations do not show any extraordinary weather. The month will average a little colder than usual for the time of year, with some quite cold snaps which will carry frost to the Gulf States."	"Over the Central Ohio Valley, and in the South Atlantic States, except along the South Carolina coast, the mean temperature was slightly below the normal. . . . In all other districts [20 in number. —ED.] the mean temperature was above the average." A few frosts usually occur in the South, even in Florida, in November.—ED.
"There will be considerable pleasant November weather scattered through the month. There will be about the usual number of storms during the month, some of which will be moderately severe, especially about the 10th."	It takes no cosmogono-astronomico-geologico-chemico-physical-geographico-mathematico-electrical learning to predict this. The worst storm of the month was on the 23d and 24th.
"The amount of precipitation	"In South Carolina, Georgia, and

will not be large, and will average a little below the normal, except in some places near the Gulf of Mexico and the Southwest, where there will be a small excess. In parts of the North and Northwest there will be considerable deficiency, and a good part of that which does fall in said tract will be in the form of snow."

Florida the rainfall has been decidedly below the average... There is also a region of deficiency which extends along the northern border of the country from northern New England to Dakota . , . in a southwesterly direction to the west Gulf States and Rio Grande Valley.... On the Pacific Coast the rainfall was remarkably heavy."

Correct!! It usually is snow, at least "in good part."

It will be seen that Mr. Blake does not even have the luck which the principles of probabilities would give him. He ought in any case to be about half right, but he is not that. If he is less than half right in other months (and I think he is), it gives rise to the suspicion that his principles do have some relation to the weather, but that he has got them wrong end to.

What his principles of prediction are, would be very hard to say. Indeed the writer has read about all *The Future*, and he is not sure whether or not Mr. Blake has yet divulged them.

PRAIRIE FIRES IN MONTANA.—The following act respecting prairie fires is in force in Montana. It will be seen that the penalties attaching to the offense are very heavy, as indeed they should be, to be of any use at all. The N. W. Council might take a leaf out of the Montana statute book regarding these fires:

Be it enacted by the Legislative Assembly of the Territory of Montana:

Section 1. That section 178 of the fourth division of the revised statutes be amended to read as follows:

Section 178. Any person who shall carelessly set fire to any timber, woodland or grass, except for useful or necessary purposes, or who shall at any time make camp fire, or shall light any fire, for any purpose whatever, without taking sufficient steps to secure the same from spreading from the immediate locality where the same may be used, or shall fail in any instance

to put out or extinguish said fire before leaving the same, shall be deemed guilty of felony, and upon conviction thereof, shall be fined in any sum not exceeding one thousand dollars, or imprisonment in the territorial prison not less than one nor more than three years, or both such fine and imprisonment, and shall be liable for all damages resulting from such act.

Sec. 2. That section 179 shall be amended to read as follows:

Sec. 179. Any person who shall wantonly or designedly set fire to any timber, wood or grass for other than necessary purposes, or who shall, from a malicious intent, fail to extinguish any fire after making the same for a necessary purpose, before abandoning the same, shall be deemed guilty of a felony, and, upon conviction thereof, shall be fined in a sum not less than one hundred dollars, nor more than two thousand dollars, or be imprisoned in the territorial prison not less than two nor more than seven years, or both such fine and imprisonment; and in all cases arising under this and the preceding section, one-half of the fine collected shall be paid to the person who shall furnish the information necessary to convict, and the other half shall be paid into the school fund of the county wherein such conviction is had.

Sec. 3. The county commissioners of each county in this territory shall annually have printed on canvas, or some other durable substance, at least fifty copies of a notice, setting forth, briefly, the offenses mentioned in this act, and the penalties herein prescribed, which said notices they shall cause to be conspicuously posted up along the highways of their respective counties.—*Montana Live Stock Journal.*

Royal Meteorological Society.—The concluding meeting of this Society for the present season was held on Wednesday evening, the 16th instant, at the Institution of Civil Engineers, 25 Great George Street; Mr. W. Ellis, F. R. A. S., President, in the chair.

The Rev. J. R. Boyle, and Mr. A. B. de la Poer Wall, M. A., were elected Fellows of the Society.

The following papers were read:

(1) "Note on a Sudden Squall, January 13th, 1886," by Mr. R. H. Scott, F.R.S. This is an account of a remarkably sudden squall of about ten minutes' duration, which passed over the south of England on the morning of January 13th. It was first recorded at Falmouth, at 8:20 A. M., and passed over London at 10:40 A. M.

(2) "The Floods of May, 1886," by Mr. F. Gaster, F. R. Met. Soc., and Mr. W. Marriott, F. R. Met. Soc. The month of May, 1886, will long be remembered for the heavy rains that occurred between the 11th and 13th, and the floods they produced over the greater part of the West and Midland counties of England. In fact, at Worcester the flood was higher than any that have occurred there since 1770. On the 11th and 12th heavy rain fell over the east of Ireland, there being over three inches during these two days at several places in counties Down, Dublin, and Wexford, the greatest reported being 3.52 ins. at Kilkeel, county Down. Over the other parts of the United Kingdom the rainfall on the 11th was under 1 inch. Rain, however, commenced falling about noon on Tuesday over the Midland counties, and continued with increasing intensity till Friday morning; the duration at most places being about 60 hours. The heaviest rainfall occurred in Shropshire, where over 6 inches fell at several stations, while at Burwarton as much as 7.09 ins. was recorded; the amounts for each day being, 0.60 in. on the 11th, 3.10 ins. on the 12th, and 3.39 ins. on the 13th. Very serious floods followed these heavy rains. At Shrewsbury the extreme height of the flood on the Severn was 16 feet, and at Worcester 17 feet 1 inch above the average summer level. At Ross the flood on the Wye was 14 feet; at Nottingham the rise of the water in the Trent was 12¼ feet; at Rotherham, the flood was 8 feet 5 inches; and in northeast Yorkshire the Derwent rose to nearly 11 feet above summer level. These floods caused great damage to property and loss of life; bridges were washed away, railway traffic suspended, and thousands of workmen thrown idle. In several places the waterworks were flooded and the towns' water supply was consequently cut off. Mr. Gaster drew

attention to the complex character of pressure distribution during the time referred to, and showed how the region of maximum rainfall followed certain of the shallow depressions which appeared over the British Islands. He drew attention to the peculiarities of this type of depression, showing how in many, if not in most, cases the rainfall was heaviest in their rear, and was brought by the easterly, not by the westerly wind. He also referred to some previous instances of heavy floods, in which similar atmospheric conditions prevailed, and explained how it was that, as the disturbance passed off, snow fell instead of rain, this in its turn being followed by severe cold, and in some places frost.

(3) "On Atmospheric Pressure and its Effect on the Tidal Wave," by Capt. W. N. Greenwood, F. R. Met. Soc. The object of the paper is to show how a little knowledge of weather forecasting, with some practical knowledge of local weather changes, and a good barometer, will go far towards forming a right correction for application to the predicted height of the tide, and also to determine what that correction should be in its relation to the fluctuations of the barometer and the prevailing gradient.

(4) "Meteorological Results at Levuka and Siwa, 1875–1885, with Notes on the Climate of Fiji," by Mr. J. D. W. Vaughan, F. R. Met. Soc. The climate of Fiji is remarkably healthy. Diseases such as fevers of an aggravated and malarious character, cholera, and liver complaints, are almost unknown.

IOWA SQUALLS.—The following extract from Dr. Gustavus Hinrichs' "Press Bulletin No. 97," of the Iowa Weather Service for June, 1881, is of value and interest in connection with the studies of thunder-storms now in progress in different parts of the country. W. M. D.

After a very heavy thunder-storm, with excessive rainfall, during the night of June 27–28, the 28th became excessively hot, the standard maximum thermometer registering the unusual heat of 93°; the barometer was low, the wind southerly, there was little cloudiness and rather high humidity. The Bulletin then goes on: "This forms a very unstable condition of

the atmosphere, during which I am apprehensive of tornadoes and squalls. . . . . Our Iowa squalls are as serious as any on the ocean; the wind may be destructive, but it is not lifting nor revolving, as it is in the tornado. Roughly speaking, the squall may be likened to an extended tornado having its axis parallel to the ground; here in Iowa it generally bursts upon us from the northwest, following the southeasterly wind; it rolls over and strikes down upon us, usually with abundant precipitation, and soon is succeeded by the same southeast [wind], which is so abruptly displaced. Such a squall was generated by the atmospheric condition above described. The front of the cloud extended from southwest to northeast. At 7 P. M., after having blown a passenger train off the track at LeMarz, Plymouth county, it carried destruction through Cherokee county; at 7:30 it struck the county seat of Iowa county; at 9:00 it raged in Calhoun and Humboldt counties; having shaken up Hampton in Franklin county, unroofing a new hotel, it reached Ames, in Story county, at 10:00; Newton at 11:00; Iowa City and Dubuque soon after midnight. The rate of progress of this terrible current was about 35 miles an hour at 8:00 P. M., gradually increasing to over 50 miles an hour near midnight. The destruction produced by this fearful squall is greatest in Cherokee county. Many houses were utterly demolished, and several persons killed. But we have no room for these sad details in our Bulletin. It may be more important to the public to mention a few additional characteristics of our Iowa squalls.

"So far as I have studied them, they come down from the northwest, progressing at the rate of 20 to 50 miles an hour. In northeastern Iowa the storm front has a tendency to bend up, so as to make the squall below more nearly from the west. In a like manner in southwestern Iowa its front bends westward and hence blows more nearly from the north. The storm front is fierce in its power along a considerable distance; 20 to 50 miles and more in its front along the earth are struck simultaneously. As the great storm front sweeps on, it generally diminishes in its fury, but at times it can be traced for 350 miles from the northwest to the southeast of our state. It is

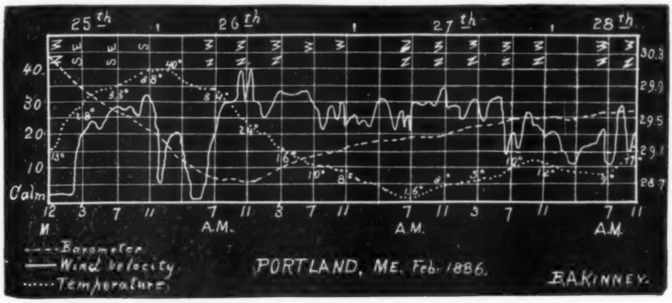
impossible to confound this storm with the tornado, which is fortunately very restricted in its field, mowing a swath of destruction, generally in a direction corresponding to the line of the squall storm front, from a southwesterly towards a northeasterly point. The tornado is narrow, local; the squall at a given instance [instant?] reaches a narrow, long, extended belt of land, like a tornado track, but this belt of destruction is carried forward with great velocity, so as to gradually sweep over a large part of the state. Again the squall of summer is radically different from the blizzard of winter. The squall comes, reaches us, and after a few minutes leaves us, moving onward in its general course towards the southeast. The blizzard blows for hours and even days. In the squall but a limited amount of air comes down from the northwest, a great roll of cold and dense air falls upon us; in the blizzard, the entire atmosphere covering several states is moving as one body towards the southeast.

"Another point which deserves attention is the fact that we may well hope in an early future to be warned of the coming squall; the squall of June 28 was disastrously well marked at 7:00 o'clock, fully three hours before it reached Ames, and five hours before it reached Iowa City and Dubuque. But the warning for tornadoes is a much more difficult problem, though not entirely impossible."

STORM OF FEBRUARY 26, 1886.—On pages 32-40 of this volume of THE JOURNAL, Mr. Pike gave an account of the remarkable ice-storms in New England since the first of January last. There was a fourth and very severe one—especially severe in Maine and Quebec—in which, however, the ice feature was not so marked as in the other three. In some places the ice accumulated on the railway tracks to the depth of six inches, but, on the whole, the storm was characterized by drifting snow. Railroad traffic was impeded for one or two days. Country roads were blockaded, and even in the towns streets were for a time impassible.

We owe to Mr. B. A. Kinney, U. S. Signal Corps, the accom-

panying diagram of the progress of the meteorological elements before, during and after this storm, as they were observed at Portland. From this it is evident that the storm was one of our familiar westerly gales which reach us with a rising barometer.



ON VERTICAL CURRENTS IN CYCLONES.*

I. What is an atmospheric whirl from our standpoint?

The prime cause of all the movements which occur in the whole of an atmospheric whirl is not, and cannot be, at the surface of the earth, nor at the limits of the atmosphere; this, that I call the whirl generator, whatever may be the cause which primarily produced it, can exist and be maintained only in a moderately elevated region of the atmosphere, where the movement of the strata is the greatest. Acting as an immense fan, this attracts to its center the masses of air above and below its own level. About its axis are then established opposing vertical currents, which, in turn, give birth, at their summit and base, to other horizontal centripetal currents; the rotation of the earth gives to these latter, by the deviations they are forced to undergo, an incipient gyration around the axis, which is more marked in proportion as the currents approach the center of the whirl which they serve to form. The masses of air in the middle region are seized by the centrifugal force developed in the whirl generator, and are then thrown out horizontally, diverging toward the bounds of the disturbed air. There, by their constantly maintained accumulation, they weigh upon the strata below them, press against those above them, and force one another toward the center, where an outlet is open to them.

In flowing water, in which case the origin of the whirls observed should likewise be sought where the movement is freest, that is, in the center of the mass of liquid, these whirls *appear* always descending, because they are seen only from above, and one is a witness only of the upper half of the entire phenomenon. It must be the same in the case of the sun, for we see only the outer surface of its atmosphere. But, upon the earth, placed as we are, at the lowest depth of our ærial envelope, it is only from below that we are able to observe the whirls which agitate it; we see only the lower half of the phenomenon, and the central vertical currents there are ascending. Thus we see that the two

*Translated from a paper by M. Dechevrens of the Zi-ka-wei Observatory.

opposing theories, concerning the direction of these vertical currents along the axis, are really one and the same, but not from the same point of view.

II. Temperature and pressure at the perimeter of an atmospheric whirl.

With this premise, let us seek the consequences of this distribution of the vertical and horizontal currents in whirls.

1. Toward the center of the whirl generator, the force exerted to cause the masses of air to descend from above, and rise from below, uninterruptedly, and then to disperse at a distance upon its perimeter, must be enormous; the heat absorbed by this work must be considerable; the temperature is then *extremely low upon the axis, in the middle region.*

2. This heat thus absorbed cannot remain free at the perimeter in the same horizontal plane, because here all the movement common to the air at the center of the whirl generator is finally lost; there is here an accumulation of air, contraction, and, consequently, heat produced. The temperature is then *raised at the perimeter, in the middle region.*

3. Under the pressure of this accumulation of air, the upper strata are raised and the lower strata pressed down. Let us consider only the latter, which alone are accessible to observation. The lower strata of the atmosphere sink, and disperse, partly without, chiefly within, the air occupied by the whirl; this dispersion over large surfaces must be accompanied by a proportional absorption of heat; there is a cooling, and the cooling is accelerated by radiation under a very clear sky. Theoretically, and under normal conditions, the descent of this air from the middle region would result in its gradual contraction, and a disengagement of sensible heat. But are we really under normal conditions in this case? Must we not rather admit that the descent of the air is due to an unstable equilibrium of the atmosphere strata, the denser being above and the rarer below? Therefore, there can be no contraction in the descent; on the contrary, as I have said, there must be expansion and, consequently, cooling. So, *at the perimeter* of the whirl, while there is an increase in temperature above, *there is a cooling* below.

We see, moreover, that observation accords with these conclusions.

4. Once having entered upon the way leading to the center, the masses of air coming from the perimeter, pressed forward from behind, strongly attracted in front, compelled finally to contract strongly under this double force, in order to penetrate to the central greatly contracted zone, in which they find the only opening that permits them to mount toward the whirl generator which attracts them, these masses of air, I say, cannot fail to be heated greatly, either by their friction against the earth or against the upper strata moving in an opposite direction, or by the friction of their own compressed molecules against one another. Naturally, it is toward, and at, the center that this heat is the most sensible. So, *at the center* of the whirl, while there is an excessive cooling at the top of the axis, there is *an intense heating at its base.*

5. Now is it necessary to dwell greatly on this to show that, in spite of the contraction of the masses of air pressing at the base of the axis, their velocity of translation, their ascensional force, and the enormous expansion which they undergo in rising toward the center of the whirl generator, amply suffice to diminish the pressure at this point? Moreover, in spite of their diffusion at the perimeter in the lower region, do not the great pressure which these masses of air support above, and the pressure which they exert in descending vertically, explain sufficiently the high pressure observed on the border of the whirl?

6. Thus, to recapitulate these different points, if we consider only the lower half of an atmospheric whirl, which, on the whole, is its principal portion, because there the great density of the air gives a greater development to all the phenomena, we find two regions of high temperature and two regions of low temperature, the former being, at first, the perimeter at the height of the whirl generator, later, the center of the whirl formed in the lowest stratum; the later are the center in the region of the whirl generator, and the perimeter in the lower stratum. In reference to pressures, they are high at the perimeter, above and below, and low at the center, likewise above and below. Only the temperatures, then, are inverted along the vertical. It is

this we must now prove by direct observations, if it be possible.

III. In a cyclone, the variations are inverted along the vertical.

1. Statement of the question.

*   *   *   *   *   *

The inversion of the variation of the temperature along the vertical *in a cyclone* must be thus understood. If, at the commencement of a cyclone, when the pressure, still high, is commencing to fall, a thermometer be carried from the level of the sea to altitudes more and more elevated, 500, 1,000, 1,500, 2,000 metres, it will probably be seen to fall a little, but *less* than would be expected. The different temperatures thus obtained at these various levels are less and less below the mean normal temperature for these levels and the season; from certain altitudes these temperatures are likewise more and more above the normal temperatures, so that, finally, it is not impossible in certain cases to see the thermometer, at an altitude of 1,000 or 2,000 metres, indicate a temperature even higher than that observed at the level of the sea.

Let us now suppose ourselves at the center of the whirl; the barometer has reached its lowest point, it is *nearly* the same the entire length of the vertical. I say *nearly*, for it is necessary to take account of a little retardation observed at very elevated stations, a retardation which we shall have occasion to notice later. This retardation, however, does not affect the phenomenon of inverted temperatures. At the base, the heat is great, and the temperature above the normal; a little higher, it is lower, then lower and lower proportionally as we rise, so that at the most elevated stations, we should find very low temperatures, much lower than the normal temperatures at the same stations.

Thus, upon the passage of the front half of the whirl, while the thermometer has been rising gradually below, it has been falling gradually above, consequently there must be a point at the center of the whirl in relation to the vertical of these various stations arranged one above the other, where the actual temperature is exactly equal to the mean normal temperature.

The question seems to me clearly put in this way. It remains for me to demand from the observations themselves the confir-

mation or disproval of these deductions. Let us commence with the phenomenon most easy to observe.

2. Comparative variation of the barometer and the thermometer at the sea level.

At the sea level the variation of the thermometer in a cyclone should be opposite to that of the barometer. To prove this, we may select an infinite number of meteorological stations of which the observations are published in extenso, either in special bulletins, or in the annual volumes of central observatories. I may be pardoned for making my selection among our Asiatic stations, the observations of which are more familiar and interesting to me. * * * * * The following table is easily understood. It shows means of all the temperatures observed, while the barometer indicated the pressure noted in the opposite column.

COMPARATIVE VARIATION OF THE BAROMETER AND THERMOMETER IN THE LOWER STRATA OF THE ATMOSPHERE.

Manilla: Lat. 14° 35′; Long. 120° 58′. 1881-1882; daily means.			Zi-ka-wei: Lat. 31° 12′; Long. 121° 26′. 1878-1883; daily means.		Tchang-kia-tchouang: Lat. 38° 17′; Long. 116° 14′. 1882-1883; daily means.	
Altitude, 21 m.			Altitude, 7 m.		Altitude, 30 m.	
Bar.	Therm.		Bar.	Therm.	Bar.	Therm.
mm.	°		mm.	°	mm.	°
766	25.9	25.50	780	—3.5	782	—8.8
64	25.1		78	—0.7	80	—4.6
	25.1	25.55	76	0.4	78	—3.9
62	26.0		74	2.0	76	—4.4
	26.0	26.35	72	2.9	74	—3.8
60	26.7		70	4.3	72	—3.5
	26.7	26.60	68	5.2	70	—2.3
58	26.5		66	7.3	68	—2.1
	26.5	26.20	64	7.8	66	—1.2
56	25.9		62	9.0	64	—0.5
	25.9	26.15	60	10.4	62	1.9
54	26.4		58	13.4	60	1.4
					58	6.0
					56	6.2

Note.—It will be noticed that at Manilla the temperature seems to decrease with the pressure from the point of 750 mm. The cause may be sought in the torrents of rain which usually accompany low pressures in the tropics. Moreover, in these countries, every rain a little heavy and continued, which withdraws them from the ardor of a devouring sun, is, in reality, a source of cooling.

Note.—Two stations, Soung-chou-tchouang and Tomsk are omitted. [ED.]

What need is there for stating the conclusion to be drawn from these different series of observations? It is evidently that which I deduced in advance from the very nature of these atmospheric whirls. It may be remarked that the variation of the thermometer is apparently in the same relation with the variation of the barometer at each of the last two stations. In effect, there is a thermometric variation, for a millimetre of pressure variation, of the following amount:

Zi-ka-wei	0.77°
Tchang-kia-tchouang	0.58

* * * * * * *

This inverse relation of the pressure and temperature in cyclones is so certain and constant, that it is easy for me to prove this with all winds, that is, from whatever point of the horizon the storm blows. The exceptional position of the Zi-ka-wei observatory, at the exact level of the sea and in the middle of a plain stretching as far as the eye can see, is especially favorable for the study of these interesting phenomena.

RELATION BETWEEN THE PRESSURE, WIND, AND TEMPERATURE IN CYCLONES.

Zi-ka-wei, Lat. 31° 12′; Long. 121° 26′.
(1876-1883).

With wind from	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
mm.	°	°	°				°	°
775–782	0 9	1.3	3.9	......	......	......	—1.6	—1.3
770–774	3.6	5.1	5.2	6.1	5.4	2.4	1.4	1.7
765–769	5.8	7.1	7.2	7.4	8.8	7.2	4.8	4.9
760–764	8.7	9.1	9.0	9.9	11.7	10.6	9.4	7.6
754–759	......	......	11.2	12.4	15.7	13.2	7.9	10.4

Farther, the wind in anticyclones is feeble; in cyclones it may be violent; in general it is stronger with low pressures than high

pressures in the lower strata of the air. From this it follows that, exclusively of the pressure, the strong winds should there be warmer than feeble winds.

* * * * * *

3. Variation of the barometer and thermometer in the middle strata of the atmosphere.

In proportion to its elevation above the lower strata of a whirl, the *inverse* relation of the temperature with the pressure must be effaced to give place insensibly to a direct relation, which would be absolute in the stratum of air where the cause of all these whirl movements acts. The proof of this important point may be said to be the touchstone of the theory of atmospheric cyclones developed in this note. But is this proof possible? It certainly was not prior to the establishment of mountain observatories. Is it since that time? Evidently this depends upon the height to which it is possible to carry instruments for observation, barometer and thermometer, and upon the relative depth of atmospheric whirls. Nevertheless, supposing, which is improbable from the number of facts duly registered, that the summit of the whirls is elevated much above our highest meteorological stations, we are able to find in the observations which have been made, at least that the inverse relation, which I claim to belong to the mere lower portion of the phenomenon, undergoes even here some change, becomes less certain, in a word tends to give place to a direct relation. Very well, we shall see that we have at the present time at hand a collection of most convincing proofs, which establish the existence of this direct relation at these relatively low altidutes.

I choose two French stations; Puy de Dome in Auvergne, and Pic du Midi in the Pyrenees; and one American station, Pike's Peak in Colorado.

The description M. Radau gives of the two former in his *Observatoires de montagne* leads me to think that we have there good conditions for observing the phenomenon in question, "The Puy de Dome is wonderfully situated as a watch tower from which to survey the country. Upon other very high mountains there may be fine views, but not an horizon completely free, as

from the summit of this peak, with the extinct volcanoes of Auvergne ranged in line eight or ten leagues distant, and overtopped by this summit." In reference to Pic du Midi de Bigorre —"this is an isolated cone of gneiss which rests upon a point far advanced from the chain of the principal central Pyrenees; it shoots up to a height of 640 m. above the group which forms its base. The Pic du Midi de Bigorre thus is exposed directly to the force of the great atmospheric waves which come from the ocean and sweep the plain of Gascony."

INVERSION OF THE VARIATIONS OF THE TEMPERATURE WITH ALTITUDE IN ATMOSPHERIC CYCLONES.

Puy de Dome. (France).

Plain: lat. 45° 46′ long. 3° 5′ E. of Paris. Alt. 388 m.
Mountain: " 45° 47′ " 2° 57′ " " 1467 m.

Plain.			Mountain.		
Barometer.	Thermometer.		Barometer.	Thermometer.	
	Winter.	Summer.		Winter.	Summer.
mm. mm.	°	°	mm.	°	°
744–742	—8.9		652–650	1.2	10.4
40– 38	—7.2		48– 46	—2.1	9.5
36– 34	—5.6		44– 42	—3.8	6.6
32– 30	—2.5	7.7	40– 38	—4.6	4.2
28– 26	—0.7	10.2	36– 34	—4.1	3.4
24– 22	—1.1	10.4	32– 30	—4.3	— 2.0
20– 18	—0.2	10.9	28– 26	—4.8	
16– 14	0 2	11.4	24– 22	—5.7	
12– 10	2.5		20– 18	—5.3	
08– 06	2.3				

It will readily be conceded without furnishing direct proofs, that these three stations, as well as others I might cite, are not in positions so exceptional that the atmospheric whirls change there all their normal characteristics, giving rise to an inversion of the phenomena observed elsewhere. What the observations show is due, not to the geographical position of these stations, but to their altitude alone. Moreover, to remove all doubts in this respect, I wish, at least for one of the mountains, perhaps the most isolated of all, and, consequently, that which will lead us nearest to the truth, the Puy de Dome, to give opposite the

observations made at its summit those made simultaneously at its base; the latter, which come under the general rule, will be the better to exhibit the contrast presented by the former. These observations are taken from the *Annales du Bureau central meteorologique de France*, for 1879, 1880 and 1881; they are, for the barometer, the observation made each day at 6 A. M., and, for the thermometer, the morning minimum.

Here is more than a commencement of an inversion in the variation of the temperature.

The observations made at Pic-du-Midi, Pyrenees, and at Pike's Peak, Rocky Mountains, of which the altitudes are each notably above that of the Puy-de-Dome, lead to the same conclusions. The former are taken from the *Annales du Bureau central meteorologique* (6 A. M. observation) and the *Bulletin international de Paris* (8 A. M. observation); the latter from the *International bulletin* of the Signal Service at Washington, and are, for winter, those of December, January and February —for summer, those of June, July and August.

Pic-du-Midi (France).			Pike's Peak (United States).		
Lat., 42° 57′; long., 2° 12′ W. of Paris; alt., 2366 m. (1881–1885).			Lat., 38° 50′; long., 107° 22′ W. of Paris; alt., 4313 m. (1879–1883).		
Barometer.	Thermometer.		Barometer.	Thermometer.	
	Winter.	Summer.		Winter.	Summer.[1]
mm.	°		mm.	°	
554–550	(— 4.8)	°	460–458	(—11.3)	°
48– 46	— 2.2	8.4	56– 54	—10.9	3.2
44– 42	— 4.3	4.7	52– 50	—12.0	—0.6
40– 38	— 6.8	1.1	48– 46	—14.4	—3.3
36– 34	— 8.7	—2.0	44– 42	—17.3	
32– 30	— 9.4	—4.0	40– 38	—20.1	
28– 26	—11.1		36– 34	—23.4	
24– 22	—13.5		32– 30	(—32.5)	
20– 18	—14.9				

Note.—The values in parentheses are the means of only two observations.

(1) For this station I confine myself, for the summer, to the three months of June, July and August, 1879; the variations are too regular to render it necessary to investigate further.

Allow me to ask whether these phenomena were known up to the present time, and known, especially, in all the generality that these observations so numerous and so concordant, taken from official records, now authorize me to give them. These are not isolated facts that I cite, but an imposing collection of observations which have served, and will still serve, I doubt not, for explaining more than one other interesting point in meteorology. Some particular cases of this inversion of temperature with altitude have been brought to light; they have attracted attention because they showed this phenomenon in a manner truly extraordinary, I might say, exaggerated; it was not only the variation of the temperature that was reversed, it was the temperature itself. While, in the plains below, winter pressed most rigorously, spring seemed to have already taken possession of the elevated peaks.

What we are now able to affirm is that, if a falling barometer, especially in winter, raises hopes of days of pleasant temperature at sea level, and the more surely as we approach the pole, yet this fall will only render more rigorous the cold already so customary on mountain tops; it is true that there will be full compensation after the passage of the center of the low. I wish to cite here at least one example of this curious action of squalls; I summarize it in the following means, which explain themselves. The table is of our two stations at Puy-de-Dome, the difference of altitude being only 1100 meters.

		Bar.	Therm.	Humid.
December 1, 1879	Summit.......	626.8	° —10.3	100 per cent.
	Base..........	720.4	— 3.3	85 "
December 23, 1879	Summit.......	651.1	2.5	34 "
	Base..........	743.5	— 7.2	79 "
Monthly means for December, 1879, for comparison.	Summit......	640.8	— 4.2	66 "
	Base..........	734.7	— 6.2	82 "

4. An objection to the preceding—Retardation of pressure minima and maxima at elevated stations.

The observations at Puy-de-Dome on the 1st and 23d of December, 1879, are not exceptional; they come completely under the general rule established by all the preceding comparisons between what occurs at the summit and base of peaks slightly isolated.

They answer in advance the objection which might be urged to all our conclusions. We notice that the daily minima and maxima of the normal variation of pressure occur some hours later on the summit than at the base of mountains. Below, the principal maximum occurs between 9 and 10 A.M.; above, it has not been observed before midday, whenever the altitude amounted to, let us say, 1000 metres.[2] Does this retardation exist also during the action of the great non-periodic fluctuations of the atmosphere? Will it occur, for example, so as to invert the pressure on the passage of a low?

Not at all, since, if the pressures were customarily inverted below and above, we should have, from all our preceding tables, high or low temperature *simultaneously* below and above.

It is important, then, to explain this particular point, and to prove what is clearly shown by the observations of December 1 and 23, 1879, already quoted, namely, that the retardation of the minima and maxima is in general inappreciable on the passage of squalls, that it certainly does not occur to invert the pressures, and, consequently, that it is necessary to admit the inversion of the temperature, as shown above.

For this proof, I have selected two groups of stations favorably located and nearly on the same vertical; these are the two stations at Puy-de-Dome in France, and the two stations of Denver and Pike's Peak in the United States. For the former two we have a difference in longitude of only 8 minutes of arc, equal to a difference of a half minute of solar time, a difference absolutely insignificant.

(2) Nevertheless on the summit of Pike's Peak, the altitude of which is 4313 metres, the barometer maximum ot the day has been observed between 10 and 11 A. M. in August and September, 1874. The hourly observations for these two months at this station are the only ones I find cited in the *Report of the Chief Signal Officer* for 1882.

For the other two stations, situated on the same meridian, the 55 minutes of latitude which separate them cannot sensibly influence the simultaneity of the barometric variation, because the general direction of low centres in the United States is almost exactly from west to east.

Puy-de-Dome (France).

Summit: Lat., 45° 47′; long., 0° 37′ E. of Paris. Alt., 1467 m.
Base: Lat., 45° 46′; long., 0° 45′ E. of Paris. Alt., 388 m:
Difference of altitude, 1079 m

	Observed means.		Dep. from the mean.	
	Sum.	Base.	Sum.	Base.
	mm.	mm.	mm.	mm.
	652	743.0	15.1	15.6
	50	41.0	13.1	12.6
	48	39.8	11.1	11.4
	46	37.8	9.1	9.4
	44	35.3	7.1	6.9
	42	34.7	5.1	6.3
	40	32.8	3.1	4.4
	38	29.4	1.1	1.0
	36	27.7	− 0.9	− 0.7
	34	25.3	− 2.9	− 3.1
	32	23.1	− 4.9	− 5.3
	30	21.5	− 6.9	− 6.9
	28	18.7	− 8.9	− 9.7
	26	16.8	−10.9	−11.6
	24	15.1	−12.9	−13.3
	22	11.6	−14.9	−16.8
	20	9.0	−16.9	−19.4
	18	8.0	−18.9	−20.4
	mm.	mm.		
Mean.....	636.9	728.4		

Rocky Mountains (United States).

Pike's Peak: Lat., 38° 50′; long., 107° 22′ W. of Paris. Alt., 4313 m.
Denver: Lat., 39° 45′; long., 107° 20′ W. of Paris. Alt., 1606 m.
Difference of altitude, 2707 m.

	Observed means.		Dep. from the mean.	
	Sum.	Base.	Sum.	Base.
	mm.	mm.	mm.	mm.
	458	638.0	13.2	10.6
	56	35.9	11.2	8.5
	54	32.9	9.2	5.5
	52	31.7	7.2	4.3
	50	30.7	5.2	3.3
	48	28.9	3.2	1.5
	46	27.8	1.2	0.4
	44	26.5	− 0.8	0.9
	42	25.9	− 2.8	−1.5
	40	24.3	− 4.8	−3.1
	38	23.7	− 6.8	−3.7
	36	22.7	− 8.8	−4.7
	34	21.6	−10.8	−5.8
	32	22.5	−12.8	−4.9
	mm.	mm.		
Mean....	444.8	627.4		

For altitudes, we have 1079 metres between the base and summit of Puy-de-Dome, and 2707 metres between the height of Denver above sea level and that of Pike's Peak. Under these conditions we cannot fail of coming very near the truth.

Notice now that I use for Puy-de-Dome the daily observations (6 A. M.) of the five cold months (January, February, March, November and December) of the four years 1879–1882, and of these the three months of January, February and December of the same years, with 1883, for Pike's Peak. I have grouped the observations taken simultaneously at summit and base, taking as

a point of comparison the observations at the summit arranged for each two millimetres, as is seen in the preceding table. In each of these columns a certain number of values, observed at the base at the same time, are grouped, of more value during the mean pressures, of less during the pressure extremes; I have then calculated the mean of these values at the base corresponding to each of the pressures at the summit. These means are given above.

The absolute amplitude of the barometric variation during these four five years' observations and during the winter, has been 35 mm. at the summit and base of Puy-de-Dome, and 28 mm. at Pike's Peak and Denver. This equality of variation of pressure at these widely divergent altitudes is worthy of note.

Now, in view of these results, I ask whether, upon the passage of atmospheric depressions, there is an inversion of pressure along the vertical? The assertion of such inversion would be in all points untenable. But, if there be no inversion of the pressure variation, it is necessary to admit as proved and absolutely certain, that there is an inversion of the temperature variation, and, frequently, an inversion of the temperature itself.

Does not this important and very interesting meteorological phenomenon testify very strongly in favor of the constitution of cyclones, as developed at the commencement of this note?

An attempt will perhaps be made to detect a proof of the retardation of the minima or maxima of pressure at elevated stations, in the fact that the amplitude of the mean pressure variation at Denver, from the preceding table, is only 15.5 mm. against 26 or 28 mm. at Pike's Peak, while I have said that, considering the absolute extremes, these two amplitudes were equal. I acknowledge that the difference is great and might well detain us some time; but without entering into a very long discussion, I shall content myself with remarking that this point does not appear in the observations at Puy de Dome, where rather the contrary takes place. It is well not to forget that Denver and Pike's Peak are far from being under the excellent conditions of Puy de Dome, which is a very isolated mountain.

I do not pretend to deny absolutely the possibility of this re-

tardation at elevated stations (3). What I believe I can hold as certain is that this in no respect weakens what I have said of the inversion of temperature with altitude, and of the causes of this meteorological phenomenon.

Pike's Peak.				Denver.		
1883.	Bar.	Therm.	Wind.	Bar.	Therm	Wind.
	mm.	°		mm.		
January 15...........	439.7	—23.3	S.W. 7m	624.8	—10.8	Calm.
" 16...........	38.6	—23.9	S.W. 2	24.3	—10.0	N.W. 5m.
" 17...........	36.4	—30.0	W. 25	22.8	—10.8	S. 3
" 18...........	31.8	—28.3	W. 13	22.0	—23.3	N.E. 3
" 19...........	33.3	—30.6	S.W. ?	27.6	—25.6	Calm.
" 20...........	29.8	—36.7	S.W. ?	23.3	—26.7	Calm.
" 21...........	34.6	—30.0	N. ?	23.8	—14.4	Calm.
" 22...........	46.3	—26.1	N. ?	29.4	+ 0.3	W. 7

It is curious that, if there be any retardation in this deep low, it is not above, but *below*, that it must be sought.

One word upon the great periods of cold which have been felt so severely during certain winters, especially in France; the months of January and February, 1882, were especially rigorous; the pressure was extraordinarily high. On these occasions there has been remarked what one might call anomalies of temperature, if there can be an anomaly where the phenomena are only natural. Thus, to cite only one example taken almost at hazard in these two exceptional months, while, at Clermont, at the base of the Puy-de-Dome on the 19th of January, 1882, the thermometer had fallen to —6.0°, with a pressure of 784.2 mm., much above the normal mean, at the summit of the mountain, with an equally high pressure of 652.6 mm., the thermometer indicated the agreeable temperature of 7.6°, a difference of about 14° in favor of the summit. Certainly there is, in this case, an actual inversion of temperature without an inversion of the pressure. These permanent anti-cyclones are explained by the same principles which have served to explain to us the temporary anti-cyclones which invariably accompany low centres. We have seen that the air which accumulates above at the perimeter of the whirl generator comes from the low centre, where it has mounted from below. At the perimeter it produces all along the vertical a high pressure; as to the temperature, this is above the mean at the summit, and

(3) There have been advanced, as a proof of this retardation exceptional cases which might have demanded discussion. Here is one which accords too closely with the *general* results to be considered an exceptional case.—I choose it, however, purposely, because it contains *the lowest pressures* observed at Pike's Peak during the period I have studied for this discussion, and also *one of the lowest temperatures* recorded at this high station.

below it at the base. All this is verified point by point in permanent anti-cyclones. Only here we are often able to find many low centres distributed about the region occupied by high pressures; these low centres occupy the neighboring seas of higher temperature; for Europe, this is, on the west, the Atlantic; on the south, the Mediterranean; on the north, the North and Baltic seas; on the east, the Black sea. From these different directions currents are formed in the *upper* regions of the air, which converge over the centre of Europe, chiefly over Germany and France. Their meeting gives rise to a disengagement of heat, which keeps the *middle strata* of the air at a temperature relatively high; *their descent without condensation* and *their diffusion* in the form of diverging currents, which return to the sea, involve an absorption of considerable heat and produce a cooling which is increased by the terrestrial radiation under a clear sky.

It is much to be hoped that this discussion of actual conditions "in the height" may be carried on till a complete result has been attained. It may be argued that the mountain itself must vitiate any results that can be obtained; however, at most this effect can be only two or three degrees, and entirely inappreciable in the result we may obtain. It is evident that, as the effect of the mountain is constant before and after a cyclone, it may be practically neglected. We cannot agree with the conclusions advanced by M. Dechevrens as regards temperature variations "in the height." The following tables exhibit a few observations collated from the same sources used by M. Dechevrens. It is clear that, if we can eliminate the effect of diurnal range from the temperature, we shall obtain much more satisfactory results than if we take observations only once each day. We may approximately accomplish this by adding algebraically to each observation the difference between the mean for the month and the mean for that observation; *e. g.*, at a morning observation, we shall nearly always need to add a small quantity, and, in the early afternoon, subtract a small quantity in order to eliminate the diurnal range. There are given mean results of ten winter storms at Puy de Dôme and thirty-two winter storms at Pic du Midi. In the first case, observations were taken three times each day, in the second, five times each day. In the first

case, five days were taken before and after the storm centre passed the summit, and in the second, three days.

TEMPERATURE IN FRONT, CENTER, AND REAR OF STORMS.

	Mean of 10 Storms, Winter, 1882.			Mean of 32 Winter Storms, 1880-1882. Observations 5 times each day.	
	Puy de Dome.			Toulouse and Pic du Midi.	
	Base.	*Summit.*		*Base.*	*Summit.*
5 days before.	6.3	1.2			
	6.3	1.4		7.4	—4.1
	5.8	1.1		7.4	—4.4
4 days........	5.4	1.3		6.7	—4.2
	5.1	0.6		7.4	—3.8
	5.0	0.4	2 days.........	7.5	—3.8
3 days........	5.4	1.0		7.6	—2.9
	8.4	0.9		7.9	—3.2
	7.7	1.1		8.0	—3.2
2 days.......	7.3	0.7		8.1	—3.1
	7.1	1.1	24 hours.......	8.4	—2.8
	9.3	1.0	12 hours..... ..	8.6	—2.2
1 day.........	9.8	1.0	9 hours..........	9.1	—2.1
	9.2	1.2	7 hours..........	9.4	—2.3
	7.5	0.7	3 hours before..	9.1	—2.9
Center........	8.8	0.6	Center.............	9.2	—2.8
	8.5	0.5	12 hours after...	9.6	—4.4
	10.0	0.2	15 hours..........	9.2	—5.5
1 day.........	8.3	—0.1	17 hours..........	8.3	—6.4
	6.1	—1.0	21 hours..........	7.4	—6.1
	5.8	—1.5	1 day...............	7.9	—5.5
2 days.........	6.1	—1.2		8.1	—5.2
	5.8	—1.0		7.9	—5.1
	6.2	—1.9		8.0	—4.6
3 days.........	5.8	—1.7		7.9	—4.8
	5.7	—1.9	2 days.............	7.3	—4.9
	5.6	—1.3		7.8	—3.8
4 days........	5.4	—1.0		8.4	—3.8
	4.9	—0.5		8.1	—3.4
	5.9	—0.3		8.1	—2.9
5 days after...	6.4	—0.3		8.0	—2.7
	6.7	—0.2			
	5.9	—0.3			

An examination of these results will show only slight changes at Puy de Dome, as was to be expected, since the difference in

elevation is very slight. On the other hand, at Pic du Midi, the effect of the approaching storm is very marked at both base and summit, the temperature rising about the same amount at both, though falling much more at the summit after the cyclone had passed.

A partial explanation of the difference between the above table and that of M. Dechevrens may be the following. A low temperature at the summit tends to contract and depress the air beneath it, and a high temperature just the reverse. There is then a tendency to an inversion of temperature, i. e., at the summit, high temperature may accompany high pressure and low temperature, low pressure, while at the base, we know that low temperature accompanies high pressure and the reverse. We entirely agree with M. Dechevrens result for pressure "in the height" though it should be noted that this is directly contrary to theory, which demands that in the center of a cyclone the heated air should rise, and reach finally a point "in the height," where, instead of a diminution of pressure, there begins to be an actual increase. This last question is an intensely interesting one.

At what point in any cyclone should we look for this change? Cannot limiting heights be settled upon between which the change, if there be one, must take place? Must not this point be beneath some of our highest stations, e. g., Pike's Peak, so that we may check this theory? Cannot some computation be made from known temperature conditions below the summits of our high stations which will indicate the amount of this increase of pressure on the approach of a cyclone center? The evidence certainly is very strong against the theory.--[Ed.]

ON THE METHOD OF CLOUD FORMATION IN CYCLONES.

The first thing necessary to form a satisfactory explanation of cloud formation in cyclones,* is to gain an idea of the way in which air movements take place in cyclones.

* The term cyclone is here used to denote, not a violent whirl of wind only a few hundred yards in diameter, but those air circulations covering thousands of square miles, which are continually passing over the country, and are called by the Signal Service "areas of low pressure."

The many synoptic charts collected over the world show that the air near the earth's surface has a motion around, and inclined toward the centers of cyclones; and numerous observations on cirrus clouds show that the upper air also has a tendency to move around, but outward from the center.

The question then arises,—does the air move to the center, rise there, and then move outward? If so, the surface air near the centers of cyclones would have to move much faster than the air near the exterior of the cyclone. The circumference of a circle with a radius of 800 miles is four times as great as the circumference of a circle with a radius of 200 miles; consequently, if the air near the exterior of a cyclone were to move along the earth's surface to the cyclone center, it would have to move four times as fast at a distance of 200 miles from the center as it did at a distance of 800 miles.

An examination of a number of cyclones in the United States has shown me that the average velocity of the wind at a distance of one hundred or two hundred miles from the center of cyclones is not very much greater, and sometimes not as great, as at a distance of 800 miles from the center.

It seems evident, then, that all of the exterior air does not pass along the earth's surface into the cyclone center. The alternative must be, that part of the exterior air rises and approaches the center in an ascending, inward, spiral motion around the center.

Prof. W. M. Davis informs me that when cyclone centers were to the south of Mt. Washington he has found cases where the temperature was higher at the top of the mountain than at the low level stations surrounding it. One of his pupils, Mr. Dewey, compared the temperatures observed on Mt. Washington with those observed at lower stations, and found that the average vertical decrease of temperature on the north side of cyclones is less than in any other part, and that the vertical decrease of temperature is greatest when Mt. Washington is in the southern part of cyclones.

The vertical decrease found in the northern part of the cyclone was too small to have been produced by a vertical ascent of air.

All of this favors the conclusion, if it does not prove, that the air felt on the top of Mt. Washington when it is north of the cyclone center is air which has come from a southerly latitude, and is slowly ascending as it moves around the center of the cyclone, while air felt on the top of the mountain when it is south of the cyclone center is slowly ascending air from a more northerly latitude than the lower air.

Now, air in rising expands; and, as a result of the expansion, cools, and condenses its vapor into cloud and rain when the expansion is carried to the proper limit.* Consequently, when the air, in moving upward and inward toward the center of the cyclone, reaches a certain level, it will be condensed into vapor, and will form around the cyclone a widely-extending stratum of watery clouds.

The air, however, cannot always move inward toward the center; but, after reaching some point near the center, and at a certain distance upward, it must begin an outward movement. At this height the temperature is very low, and any superfluous vapor which the air may contain will be frozen. Accordingly, in this upper current is found a thin stratum of frozen clouds slowly dissolving as it moves outward far to the front of the cyclone.

Thus there is a general tendency to the formation around every cyclone of two strata of clouds, one of which is composed of water particles formed in the lower spirally inward, upward moving air; while the other is formed of ice particles in the upper, outward moving air.

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* The production of cloud particles by the mere expansion of ordinary air is a result which is not only in accordance with the known laws of physics, but Espy and others have demonstrated it by actual experiment. Espy states in his Fourth Meteorological Report, that he connected two receptacles together, one of which contained ordinary air; while from the other, as much of the air as possible had been exhausted by the air-pump. On turning a stopcock, and suddenly allowing the air in one to exhaust into the other, the air became filled with little cloud particles of condensed vapor. Aitkin and others, in England, have recently repeated these experiments, and find that to produce a cloud, it is necessary for the air to contain fine dust particles on which the vapor can condense.

This condition is found more or less existent in all cyclones, but is subject to many modifying influences. One of the most important of these, perhaps, is the difference of latitude of the various parts of the cyclone. In the northern hemisphere, air coming from the south and south-east of the cyclone center is usually warm and moist; and, in moving spirally inward and upward, is carried around to the front and to the north of the cyclone center. This fact of greater moisture, combined with the fact that the air is moving from a warmer to a colder climate, causes the greatest amount of condensation of vapor into cloud and rain to occur in the front of cyclones; and the least in the rear, where the air is colder, and dryer, and comes from a colder to a warmer climate.

Another modifying condition is the distribution of land and water. Cyclones coming from the Rocky Mountains in the United States, have the large bodies of water to the south and east—just the position to cause the greatest condensation to take place in front of cyclones. In Europe, the largest body of water is in the rear of the cyclone, and, as a consequence, the condensation is greatest to the south, and almost as large in the rear as in front of the center of the cyclone.

Another most important condition is the retardation of the lower air in cyclones by friction against the earth's surface. It is a well-ascertained fact that the velocity of at least the lower air rapidly increases as the distance above the earth's surface is increased. As a consequence, air moving spirally into a cyclone, and upward, would, after it had reached a height above the earth's surface, overrun air ahead of it moving more slowly near the surface. Air coming from the south and overrunning air to north, would be in stable equilibrium: but air coming from the north would overrun air in the southern half of the cyclone that was warmer than itself; the equilibrium would be unstable, and the lower air bursting up through the warmer would destroy the tendency to a uniform cloud stratum, and produce clouds of a considerable vertical height, with clear spaces between them where the cold air descended. Thus, I think, are produced the cumulus clouds of the southern half of the cyclone—at least in

their most striking forms, such as are the accompaniment of the thunder-storm and the tornado. Thus, too, a large part of the moisture in the southern air is condensed before it reaches the eastern part of the cyclone.

Another modifying condition is the seasonal variation. Cumulus clouds tend to be produced whenever the vertical decrease of temperature with height exceeds a certain amount; and in summer this result may be reached independently of cyclone action, so that cumuli may appear in any part of the cyclone, though chiefly confined to the southern half: but in winter, outside of the tropics, the ordinary decrease of the temperature with the height is much less, and the tendency to the formation of a uniform cloud stratum over the sky within cyclones is at its maximum.

Another modifying condition in the temperate zones is the general drift of the atmosphere, which especially seems to interfere with the circulation of the upper air, and causes the upper stratum of clouds to extend far out to the front, and but a short distance to the rear of the cyclone center.

Sometimes the regularity of the cloud formation is interfered with by the formation of secondary cyclones within the main cyclone.

Frequently in winter, and sometimes in summer, the lower cloud stratum is absent, especially on the front and north side of poorly-developed cyclones, and there is simply a single stratum of cloud increasing in density from the edge to the center of the cyclone.

H. HELM CLAYTON.

CAMBRIDGE, MASS., January 18, 1886.

ON WAVE-LENGTHS HITHERTO UNRECOGNIZED.*

The temperature of the surface of our planet depends on the properties of radiant heat and on its relations to the action of our atmosphere. This action has been compared to that of the glasses of a hot-bed, but I have lately shown that the air does

* By Professor S. P. Langley; translated from the *comptes rendus* and bearing date of January 18, 1886.

not behave like glass which transmits less of the dark than of the luminous solar heat, except the absorption bands, (which correspond to solar waves up to an extreme of $0^{mm.}$ .0027, as given in *comptes rendus,* September 11, 1882), the air is not athermanous, but becomes more diathermanous for *solar* heat up to the greatest wave-length observed. It is then necessary to revise our ideas on the way in which the solar heat is stored up to sustain organic life, and it is of the highest interest to determine the wave-lengths of heat emitted by a body having the temperature of the soil.

Since the presentation of the memoir cited above, I have occupied myself with the spectra produced by sources of heat of all temperatures, from that of fused platinum to that of melting glass, and especially with spectra formed at the low temperatures which correspond to the ordinary conditions of the soil, I have been led to recognize the existence of wave-lengths, not yet measured, which I have not yet found in solar heat, even in the extremest infra-red waves. It is necessary above all to here distinguish what has been long known from what has been shown recently, and from what is to be now given for the first time.

Newton's measures, translated into terms of the prevailing theory, give (approximately) wave-lengths from $0^{mm.}$ .0004 in the violet to $0^{mm.}$ .0007 in the red. M. Cornu has shown that the extreme ultra-violet solar radiations that reach us have a wave-length a little less than $0^{mm.}$ .0003, while ultra-violet waves from terrestrial sources have been observed with a length of a little less than $0^{mm.}$ .0002.

As to the infra-red, with which we are here especially occupied, physicists generally believed, up to 1882, that no waves had ever been observed of a greater length than $0^{mm.}$ .0010.

Until quite recently then the limits of known spectra, from all sources celestial or terrestrial, were from about 2000 to 10000 on Angström's scale, (or $0^{mm.}$ .0002 to $0^{mm.}$ .0010), and even last year so competent a judge as M. Becquerel maintained that the greatest radiations, experimentally demonstrated, did not attain a wave-length greater than $0^{mm.}$ .0015. As the exactness of my former measures up to $0^{mm.}$ .0027 has been recently recognized,

I will recall, as a reminder only, that I published, in the *Annales de Chimie et de Physique* in 1884, a minute description of the means I employed.

I will reserve for a subsequent publication the detailed description of the apparatus and methods on which are based the new determinations I am about to give, and I limit myself here to presenting the principal results of the studies instituted at the Allegheny Observatory in this direction since 1882, especially on the spectra of dark bodies not hitherto, as far as I know, experimentally determined.

Suppose that the heat of each source examined be represented by a curve like the figure 2 in the above mentioned memoir of the *comptes rendus* in which the scale of abscesses is directly proportional to the wave-length. It appears from this figure that the solar heat ceases to be sensible at a wave-length of $0^{mm.}$ .0027, and the first question naturally presented is this:—*These solar wave-lengths of the infra-red, which doubtless correspond in part to the spectra which would be found in dark bodies if we could study them,—do they comprise all the wave-lengths which are emitted by terrestrial bodies of all sorts?*

I have observed that:—

1.—The heat represented by the areas of such curves, constructed on the spectra of *cold* and dark bodies, is lacking even in the extremest infra-red undulations. In every case, the point of maximum of heat from these dark sources has a wave-length greater than Angström's 27000, that is lower than the lowest solar heat known to reach us.

2.—An increase of temperature augments all the ordinates, but not in the same proportions, and the progressive motion of the maximum of heat in the spectra of dark bodies as the temperature is raised seems satisfactorily demonstrated, though recently denied.

3.—The curves are not symmetrical. The larger part of the area, or of the heat represented, is lower than the maximum,—that is on the side of the greatest wave-lengths.

4.—Almost all the heat spectrum from these sources traverses a prism at angles which the rather empirical theories of the books has heretofore declared impossible.

My resources have been directed to sources of heat between 100° and —2°, the radiations being received on a cooler body. I do not give here absolute values; I limit myself to saying that the smallest value for the maximum heat in the spectrum of melting ice is, in all cases, greater than 50,000 on Angström's scale. This is of course only for the maximum heat of such a spectrum, but my experiments make it extremely probable that we can recognize with the bolometer waves whose length could not be less than 150,000 of Angström's scale. It is not that these wave-lengths are already actually determined. I limit myself here to minimum values, the possible limits of error of which will be established later in a more extended memoir. They are, in fact, sufficiently remarkable to make us prudent; but, speaking here with the reserve imposed by the necessity of brevity, I may say that everything leads me to believe that the radiations whose inferior limit Newton put at $0^{mm.}$ .0007, a value which has undergone little change until very recently, have been extended by these researches up to $o^{mm.}$ .0150. This is more than twenty times Newton's limit and partly fills the great gap which has existed between the lowest known vibration of light and the highest of sound.

While hoping that these conclusions may not be without interest in pure physics, I think they may afford the astronomical physicist a more fruitful means of employment in the future. I hope to determine the nature of the processes, heretofore unknown, which preserve the temperature of the surface of our planet, and defend the existence of organic life against the cold which, without this, would result from the too free radiations of the soil into space.

ORIGIN OF THE RED GLOWS.

[*Continued from the* JOURNAL *for July.*]

As to the height of the column of ejecta emitted from Krakatoa at its highest activity, some estimate may be formed from known facts. The heaviest throes were very precisely determined (*l*) to have occurred at 9:55 and 10:45 A. M. on August

l. Nature, vol. 30, p. 12.

27th. The latter one was immediately followed by a continuous downpour of mud and ashes upon the ship *Charles Bal,* then 30 miles distant. (*m*) Seventy miles away, trees were extensively shattered by the weight of wet ashes. (*n*) Batavia, 100 miles away, was covered three inches deep with white ashes during the hours of total darkness following the greatest eruption. It seems impossible to find room for these facts on any estimate of the height of the eruptive column as less than one hundred miles. It is true that *light* ashes might have great lateral diffusion from a column of far less height, but mud and wet ashes must have plunged quite directly downwards, so that a lateral throw of 30 to 70 miles must involve a vertical ascent of not less than one hundred.

The height supposed would have driven the eruptive column entirely through the atmosphere and far above it, so as to deliver its contents over the surface of the atmosphere, to settle slowly down through its upper strata.

That the great column did actually thus lift and rend asunder the mighty mass of the atmosphere above the crater is made probable by the unique oscillations of the barometers. A series of atmospheric waves was sped three times around the globe at the rate of 700 miles an hour. (*o*) The length of each undulation was one million meters, that of the lowest audible sound waves being 24 metres. Twenty miles away from the crater the mercury rapidly oscillated between the 28th and 30th inches. It is thus evident that in the vicinity of Krakatoa the upper layers of the atmosphere were swinging up and down through a vertical distance of from ten to twenty miles every 15 minutes. What could have done this less than an explosion driving clear through its entire depth?

As general evidences of the ultra-colossal character of the Krakatoa explosion, may be adduced the following: 1. The waves driven upon the coasts of Anjer and Merak, 30 miles away, were

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m. Nature, vol. 29, p. 140.
n. Leisure Hour, July, 1885, p. 487.
o. Nature, vol. 29, p. 181.

found to have exceeded 35 meters, or 112 feet, in height. (*p*). Over the entire Anjer plain, fifteen miles by five, the inundation had uprooted every tree, and coral blocks of from 20 to 50 tons in weight had been torn from the bed of the sea and borne inland two or three miles. (*q*).

2. The detonations of the eruption were heard throughout a circle whose radius is 1,800 geographical miles (*r*), equal to one-fifteenth of the surface of the earth's surface. Yet the heaviest could not be heard within a radius of 40 miles from the crater. The sounds must have proceeded from tremendous rendings of the air at an immense height, whence the sounds were easily spread to vast distances, while from localities beneath, the massive torrents of descending ejecta cut off the sounds like a wall.

3. Ashes (*s*) at Singapore, 335 miles; at Buncalis, 915 miles north-west; at Keeling, 1,200 miles south-west; on the Australian coast, 1,050 miles east-south-east; on the Arabella, 970 miles west-north-west. The entire area of ash-fall was officially estimated as at least 750,000 kilometers (*t*), or as large as the Southern States east of the Mississippi.

The history of the eruption shows that upon the collapse of the mountain, on the morning of the 27th, the eruptions became submarine (*u*); the ocean water rushed into the burning depths. Under the pressure of many miles of water the lava and the waters commingled and struggled with geyser-like discharges of augmenting violence, until finally there arose a continuous column of white-hot water and lava. Through the wide throat, apparently three miles in diameter, the vast column drove upwards, expanding and exploding as it flew into steam and pumice, till reaching one hundred miles or more in height, its mingled solids and liquids had exploded in the vacuum into thinnest ether.

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p. *Nature*, vol. 30, p. 14; *Leisure Hour*, Sept., 1885, p. 636.
q. *Leisure Hour*, August, 1885, p. 556.
r. *Nature*, vol. 30, p. 10.
s. *Nature*, vol. 30, p. 13.
t. *Nature*, vol. 30, p. 13.
u. *Nature*, vol. 30, p. 12.

The ashy ejecta, as analyzed, were mainly of glass in the form of pumice, together with the solid constituents of sea-water (*v*). This vitreous matter, being comminuted by the force of the explosions to dust of ultra-microscopic fineness, formed, together with the vaporized sea-water, a vast bulk of extreme tenuity and lightness above the atmosphere. Falling thence upon the upper strata of the atmosphere, and precipitating its coarser dust, its finer portions have continued suspended for more than two years in their ethereal encampment, and are likely to abide there for many years to come.

From the beginning the white sun-glow has been very uniform, while the night-glows have been quite irregular, although it is believed they have always been perceptible. In the northern tropics, there has been a marked inrease of brilliancy and continuity during each of the two winters. Probably the haze is distributed through the atmosphere in unequal and irregular drifts.

John Aitkin's demonstrations of the necessity of dust nuclei to the formation of ice spicules in the atmosphere (*w*), indicate that such ice-particles probably play a prominent part in the Glows. Not improbably they would be in larger quantity in the tropics during the winter, and so the Glows increase at that season. Varying atmospheric conditions would also at all seasons vary the amount of congelation.

In conclusion, the writer takes the opportunity to venture the surmise that a thorough study of the Krakatoa smoke-belt of September, 1883, and of its dynamic conditions, may furnish material aid in elucidating the still mysterious problem of the Belts of the planet Jupiter.

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HAWAIIAN ISLANDS.

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v. *Nature*, vol. 30, p. 13.
w. *Nature*, vol. 29, p. 463.